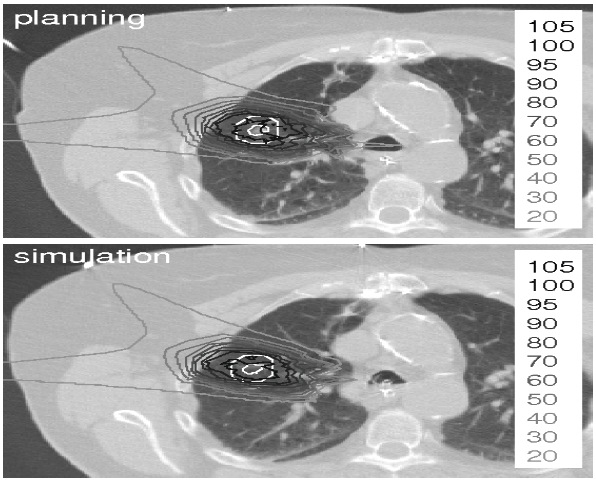
OC-0341: Robustness of swallowing-sparing proton therapy for head and neck cancer

Laan, H.P. van der; Brouwer, C.L.; Korevaar, E.W.; Veld, A.A. van 't; Sijtsema, N.M.; Langendijk, J.A.

DOI:
10.1016/S0167-8140(15)32647-5



Results: Mean(standard deviation) V95 of the PTV of all plans was 98.6(4.3), and 94.7(5.8) in the recomputed plans on the localization CT (p=0.007). V95 for the GTV was 99.6(4.1) and 99.0(4.7) on the localization and the planning CT, respectively; this difference was not significant (p=0.0549). V98 for the GTV was 82.3(10.9) and 83.5(13.6) on the localization and the planning CT, respectively; this difference was again not significant (p=0.1483).
Conclusions: The coverage of the PTV (5 mm margin) was significantly lower in the recomputation on the localization CT, whereas V95 and V98 of the GTV remained unchanged in this group of patients. The clinical relevance of these changes remains to be elucidated. Jet ventilation appears to be a feasible technique for irradiation of small peripheral tumors with proton therapy. The study of new planning strategies and margin concepts is warranted.

OC-0341
Robustness of swallowing-sparing proton therapy for head and neck cancer
H.P. van der Laan[1], C.L. Brouwer[1], E.W. Korevaar[1], A.A. van 't Veld[1], N.M. Sijtsema[1], J.A. Langendijk[1]
[1]*University of Groningen / University Medical Center Groningen, Department of Radiation Oncology, Groningen, The Netherlands*

Purpose/Objective: Proton therapy is more sensitive (less robust) to geometrical uncertainties than photon therapy. Different methods have been proposed to increase proton plan robustness. These methods include robust CTV-based planning as an alternative to conventional PTV-margin based planning. Thus, different changes will be combined in the intended improvement for proton therapy. The purpose of this study was to test the robustness of scanned-beam intensity-modulated proton therapy (IMPT) to setup errors and geometrical changes compared to IMRT for head and neck cancer if conventional PTV-margin based planning would be used.
Materials and Methods: In 10 patients with laryngeal or pharyngeal cancer, a planning-CT (CT_0) and a repeat-CT scan (CT_1) during the course of radiotherapy were made (median interval 25 days). Five patients had relatively small shape changes and 5 patients had relatively large shape changes. Target volumes were delineated on CT_0, including a uniform 5 mm margin from CTV to PTV. IMPT and IMRT plans were made with optimal sparing of the parotid glands and swallowing organs at risk (SWOARs). Structures were propagated from CT_0 to CT_1 after deformable image registration. Subsequently, rigid registration and plan reconstruction on CT_1 was performed simulating: 1) no correction for setup errors; 2) off-line correction; and 3) on-line correction.
Results: Planning objectives (including strict criteria for target coverage and dose in critical structures such as the spinal cord) were fulfilled in all plans on CT_0. Coverage of the CTV was adequate with IMRT on CT_1 regardless of the correction method, and with IMPT after on-line position correction. In two patients, the tumour-CTV shrunk with 25% and 28%, respectively. With IMPT this resulted in a spinal cord dose that exceeded the tolerance dose (it ranged from 55.0 Gy to 62.5 Gy in these two cases with the different position correction methods). The mean parotid gland dose was lowest with IMPT on both CT_0 and CT_1, but increased on CT_1 with IMPT more than with IMRT (see table). The mean dose in the SWOARs on CT_0 was lowest with IMPT. On CT_1, the mean dose in the superior pharyngeal constrictor muscle was lowest with IMPT and the mean dose in the supraglottic larynx was lowest with IMRT. The influence of the setup correction method on the mean parotid gland and SWOAR dose on CT_1 was relatively small. Dose changes in OARs were mainly caused by changes in patient geometry during the interval between CT_0 and CT_1.

	CT_0		CT_1	
	IMRT	IMPT	IMRT	IMPT
Small shape changes (n=5)				
Ipsilateral parotid mean dose (Gy)	35.4 (±19.9)	32.2 (±21.0)	39.2 (±19.0)	36.5 (±20.6)
Contralateral parotid mean dose (Gy)	15.5 (±6.9)	12.1 (±6.3)	16.1 (±7.5)	14.2 (±7.3)
Superior PCM mean dose (Gy)	57.3 (±16.8)	54.3 (±21.9)	57.5 (±16.4)	55.5 (±20.7)
Supraglottic larynx mean dose (Gy)	59.1 (±7.6)	58.3 (±7.8)	58.8 (±9.6)	60.8 (±9.4)
Large shape changes (n=5)				
Ipsilateral parotid mean dose (Gy)	51.1 (±11.8)	47.2 (±15.4)	51.7 (±12.8)	50.9 (±17.4)
Contralateral parotid mean dose (Gy)	22.0 (±13.2)	14.0 (±11.1)	23.4 (±13.0)	18.2 (±14.2)
Superior PCM mean dose (Gy)	58.0 (±15.1)	55.9 (±15.3)	58.5 (±15.0)	58.4 (±15.9)
Supraglottic larynx mean dose (Gy)	49.0 (±20.6)	43.5 (±24.9)	49.7 (±21.1)	52.1 (±24.0)

Mean dose values with simulation of on-line position correction

Conclusions: With conventional PTV-margin based planning, IMPT would be less robust to geometrical changes than IMRT, resulting in reduced gains with regard to the mean dose delivered to OARs on CT_1. Adaptive CTV-based treatment strategies are expected to fully exploit the benefits of IMPT, especially for patients with large geometrical changes. This study defines a reference to quantify the benefit of these proton strategies.

OC-0342
Anatomical changes in mesothelioma patients: effect on proton dose distributions and benefits of early replanning
S. Lorentini[1], G. Fava[2], P. Vitali[3], F. Fellin[1], S. Tonoli[3], M. Amichetti[2], M. Schwarz[1]
[1]*ATreP Agenzia Provinciale per la Protonterapia, Medical Physics, Trento, Italy*
[2]*ATreP Agenzia Provinciale per la Protonterapia, Radiation Oncology, Trento, Italy*
[3]*Spedali Civili, Radiation Oncology, Brescia, Italy*

Purpose/Objective: 1)To evaluate the dosimetric effects of anatomy changes in patients affected by malignant pleural mesothelioma (MPM) on intensity modulated proton therapy (IMPT) plans and 2) to propose an approach to mitigate this effect.
Materials and Methods: The study was based on the planning CT and either 3 or 4 verification CT scans acquired during the course of the treatment of five patients treated with trimodality approach (surgery + chemo + radiationtherapy). CT scans were registered with automatic rigid registration on bony anatomy. Structures' contours were copied on the verification CTs and manually adjusted by a radiation oncologist. Changes in the volume of air pockets within the CTV over the treatment course were quantified.
For each patient, a 2-fields IMPT plan was generated on the planning CT in our TPS (Elekta XiO 4.64) and then re-calculated on the verification CTs. Several dosimetric indexes for PTV and OARs were used to quantify the differences between planned and recalculated dose distributions (see table).
As a term of comparison, for one patient an IMRT plan was designed on the planning CT and then recalculated on the verification CTs.
The effect of replanning early in the treatment cycle was evaluated by replanning on the first control CT (taken after about one week of treatment) and then recalculating on the remaining control CTs.
Results: The CT data showed a systematic reduction of the air volume in the CTV over the treatment course: the mean reduction between planning CT and last control CT was 80±13% (range: 63-100%). The dosimetric impact on the planned dose distributions is summarized in table. A decrease of V98 in the CTV up to 17.2% was observed, along with an absolute +24% in V107. Dramatic discrepancies were not observed for OARs: the typical increase in mean dose for liver and ipsilateral kidney was 2Gy and 3Gy, respectively. However relative differences up to 40% were found in V40 for oesophagus. The IMRT plan provided similar results as IMPT concerning target coverage, while for OARs it is more robust. However even after the last recalculation IMPT is still better. When IMPT treatments were re-planned on the first verification CT and then recalculated on the remaining verification CTs, smaller differences were found (see figure), especially concerning the target coverage (on average V98 decreased only by 4.7%). For both the liver and ipsilateral kidney the mean dose increase was less than 1 Gy. A 4D-CT scan was acquired for one patients to assess intrafraction organ motion. Results showed no impact.